



HEAVY METAL

EARTH'S MINERALS AND THE FUTURE OF SUSTAINABLE SOCIETIES

EDITED BY
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and dust settling at the end of the piece. The geographic coordinates are represented throughout, and there is a theme exploring labor, and a chorale for reflection. Near the end, some notes are interrupted, like the intermittent reception of a cell phone. The final chord is restful, yet also has an element of the unresolved, for there is lots yet to discuss and negotiate. Through this composition, I hope to articulate our complex relationship with lithium and the digital technologies it enables, while inspiring a less-Eurocentric approach to envisioning a sustainable future.

Silicon

Chris Chafe

After oxygen, silicon is the second most abundant element on Earth. The Planet's crust is rich in silicate minerals, like quartz, which contain atoms of silicon and oxygen bonded together in crystals. By comparison, the pure elemental form of silicon is much rarer in nature. The super-flat, shiny and exceedingly pure silicon wafers used for electronic components are only a recent human invention. They are produced by refining silica sand into pure blocks of silicon, which are sliced into sheets about the thickness of a human fingernail. Over the past half century, these thin silicon wafers and their embedded circuits have provided a literal backbone for the growth of digital technologies around the globe.

The semi-conducting properties of silicon have made it an essential building block for ever denser electronic circuits, which switch current on and off at extremely high speeds. The three-year-old laptop on which I composed the silicon movement of the *Heavy Metal Suite* contains several billion transistors. Today, a processor chip in a new laptop has twenty billion or more transistors, approaching the number of neurons in the human brain (about one hundred billion). Although a transistor isn't a neuron, the scale of the circuitry that can be built with silicon is nonetheless remarkable. Equally

remarkable is silicon's ability to harvest energy from the Sun; silicon wafer technology is used in 95% of the solar panels in the United States, and solar power currently provides as much commercial electricity as the country's entire hydroelectric supply.

My home, near the San Francisco Bay in northern California, is in Silicon Valley, one of the world's great research and development hubs for digital technologies. Despite the name, no silicon is actually mined or processed there. It is a place for mining of a different sort, known worldwide for its deposits of cash (not sand) and synonymous with techno-investment. The history of this region has been shaped, time and time again, by change and upheaval; from earthquakes, mountain building and sea-level rise, to colonialism, climate change and globalization. All of these forces, whether slow-paced or cataclysmic, natural or human, have made the place what it is today; an area with stories that need to be told. On the surface, it is a resplendent, affluent place. Without reflection, you wouldn't know that its ancient trees had been completely clear cut, its animals wiped out and the first inhabitants horrifically ill-treated.

Before computers, Silicon Valley was the home of Indigenous populations who, for millennia, used silicon in its natural mineral forms for tools and other purposes. Spain's colonization of Alta California caused abrupt, extreme upheaval, initiating several centuries of subjugation and displacement of Indigenous peoples, and wanton resource and labor extraction.¹ The story of this colonialism has been largely silenced in the dominant historical narrative. But that is now slowly changing, as descendants of the early inhabitants are driving a new awareness of the dynamics of exploitation and consumption, global political economies and the limits of nature's resources and resilience.

The silicon movement of the *Heavy Metal Suite* was inspired by the properties of two substances; sand and pure silicon. As a starting point, I created three-dimensional software models representing the chaotic distribution of sand grains, as compared to the regular lattices of silicon atoms in their pure crystalline form.

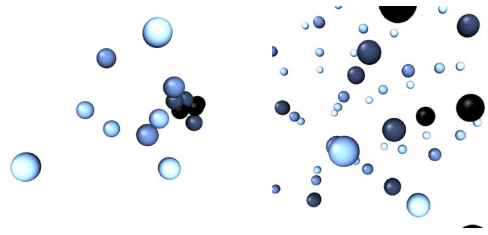


Fig. 4a–b Three-dimensional software models representing the chaotic distribution of sand grains (left) and the regular lattices of silicon atoms in their pure crystalline form (right). Images created by Chris Chafe (2024), CC BY-NC.

To represent these graphical designs in a musical form, each point in the diagrams was translated into features in the score for each member of the brass quintet. The models are allowed to change over time as their particles move through space. This movement is then mapped musically into dynamic melodies, rhythms and articulations, with interlocking ensemble textures following the changing geometries of the grains and atoms. For example, a blue sphere in the graphic above represents an event assigned to the horn part. As time advances, its position changes, providing new spatial coordinates that produce new musical information. One spatial coordinate might be mapped to loudness, as a compositional choice that depends on where we are in the unfolding music. Further along, the same blue sphere might instead produce an element of a rhythmic motif. The movement's overall form is a contrasting sequence of motifs derived from the sand and lattice models, and tied together by the fundamental property of silicon—its (semi)conductivity, following the motif written by Augusta Read Thomas.

If Silicon Valley itself has a form to draw upon, it should include stark juxtapositions in a turbulent history. Unlike the smooth shiny surface of a highly-refined silicon wafer, or a real estate depiction of a picture-perfect neighborhood, the truth underneath is bumpy and wrinkled, filled with interesting textures of an Indigenous world that has largely been undone and glossed over. The silicon theme, and the software models

used in this movement, are my musical carriers for the Valley's millennia, its turbulent recent centuries, its high-speed present, and even some whispers of its possible future.

The ambiguity of interpretations from music back to an intended subject is one essence of the art form. The same music can mean different things to different ears, and even to the same listener at different times. Sometimes, music can even convey different messages at the same time. Listen to the *Silicon* movement for reflections of the Valley, how its living and natural resources have been eroded or blended, or perhaps forgotten altogether. The change of form and shape is a fundamental property of the natural world, and of human civilizations; how stones become sand, and eventually how the sand becomes the silicon wafers that have shaped our world.

Endnotes

- 1 Gustavo Adolfo Flores Santis, 'Native American Response and Resistance to Spanish Conquest in the San Francisco Bay Area, 1769–1846' (MA Thesis, San José State University, 2014), https://scholarworks.sjsu.edu/etd_theses/4462/